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REASERCH AND CASE STUDIES ON WATER LOSSES IN DISTRIBUTION NETWORKS AND THEIR EFFECT ON THE GROUNDWATER

BY

CATRINEL-RALUCA GIURMA-HANDLEY*, ALEXANDRU POSTAVARU and ION GIURMA

“Gheorghe Asachi” Technical University of Iasi, Faculty of Hydrotechnics, Geodesy and Environmental Engineering, Iași, Romania

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Abstract. The current paper approaches the possibility of using the devices owned by the Company I work for, namely the G.P.R. (Ground penetrating Radar), U.A.V., thermal imaging camera, for the purpose of pre or identification of losses on pipelines and transportation of drinking water, identifying fraudulent consumers by determining possible unauthorized digging and monitoring the sewage and treatment plants. both on drinking water distribution and transportation pipes. Using different types of GPR’s such as low frequency, GPR with deep radar penetration up to 11 m depth, GPR with multiple antennas especially those with 40 or more, can help to create a better “image” of the underground utilities, as well as the presence of possible infiltrations, which can come either from damaged pipes or from the groundwater. These equipments like G.P.R., drones and thermal imaging camera, should not be perceived as universal replacement of all the so far existing devices, either in terms of loss identification or in terms of utilities identification, as they are complementary devices on certain loss detection segments.

Keywords: best practices, drones, G.P.R., water losses.

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*Corresponding author; *e-mail*: catrinel-raluca.giurma-handley@academic.tuiasi.ro

1. Introduction

The main activities of the company that I work for namely C.J. APASERV S.A. Neamt are water abstraction, treating, transporting, storing and distributing drinking water, as well as collecting, transporting and treating wastewater.

The supply of drinking water is made for a total number of 46101 users, through the approximately 1204 km of drinking water network.

Water losses in distribution networks is a major concern for the management of our company.

Water leaks represent the amount of water introduced into the water supply system but does not end up being used for the purpose for which it was intended.

Water losses can also be defined as the difference between the volume of water entering the water supply system and the volume of water consumed and billed to users. Water losses can be classified into two categories, namely: physical or real losses and commercial or apparent losses.

Physical losses consist of: leaks from the transmission and distribution pipes, leaks and discharges from overflowing tanks (reservoirs), leaks from the connecting pipes to the user's metering unit. Apparent losses represent the amount of water consumed but not paid by consumers.

Within the company APA SERV SA there is a team specialized in water loss detection which is dedicated only to this activity and which acts within the NRW Bureau.

Type of works are detection of hidden utilities, detection of infiltrations and water loss, detections of various anomalies.

In order for me to perform those type of works I'm using different devices in the field one of them is GPR.

2. Equipment used

We have many types of GPR that were purchased by CJ APASERV SA Neamt such as DUO, Opera DUO, TR-80 (that works only at great depths,) Stream EM and RIS HI-MOD Fig. 1.

Apaserv has been making shy investments since 2004 in the purchase of specialized equipment for water loss detection.

But for this short paper I will focus on a single rather complex equipment called STREAM EM.

Fig. 1 – GPR models we use in the field.

G.P.R. – Stream EM

Stream EM is a vehicle towed radar solution for extensive 3D mapping of underground utilities and features. To accomplish this task, it uses massive arrays of multi-polarized, multi-frequency antennas. The use of a massive array enables it to perform fast scans of large areas while maintaining a high level of accuracy.

Being multi-polarized provides optimal detection of both longitudinal and transversal features without the need to perform multiple scans.

The STREAM EM system is composed of a massive series of multi-frequency, double-polarized antennas, which have the ability to recognize the three main layers that make up the asphalt surface, as well as any stratification or anomaly present between the different layers of the structure on a depth between 0 - 50cm (temporary, light, heavy) but also the depth layers 1.5 - 2m.

It can be towed by a vehicle up to15 km/h and can be run continuously without blocking traffic.

Stream EM can be interfaced with GPS or a total station in order to accurately geo-locate the surveyed area and to individually distinguish all pipes, cables and anomalies detected.

Stream EM is a modular system which can quickly be reconfigured with optional frames to suit particular requirements or constraints, Fig. 2.

Its antennas are composed of 2 vertical 200MHz Detection of Main Line (DML) arrays for detecting main pipes along the road and 4 horizontal dual frequency 200MHz & 600MHz Detection of Connection Line (DCL) arrays for the detection of shallow and deep junctions.

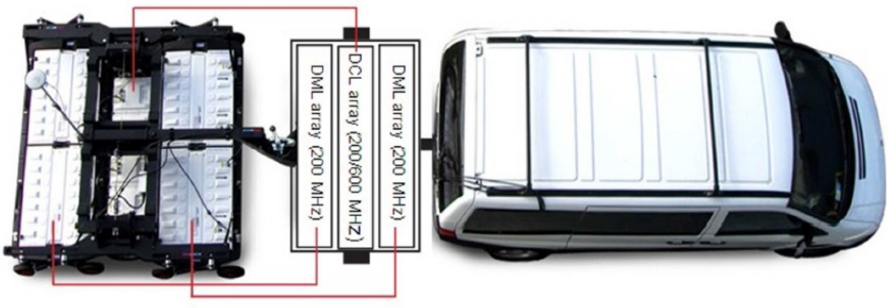

Fig. 2 – Description of a gpr Stream em.

GPR Stream-Em could, in principle, identify leaks in buried water pipes either by detecting underground voids created by the leaking water as it erodes the material around the pipe, or by detecting anomalous change in the properties of the material around pipes due to water saturation. Unlike acoustic methods, application of ground penetrating radar for leak detection is independent of the pipe type (e.g., metal or plastic). Therefore, GPR could have a higher potential of avoiding difficulties encountered with commonly used acoustic leak detection methods as it applies to plastic pipes.

3. Software being used

The software of the equipment used, can be acquisition and processing data such as: Gred HD 3D Fig. 3.

Some of the interesting features of the software are: tomographic map view (C-Scan) including radar scan fusion; advanced targeting using radarscan and tomographic view; synthetic map; radarscan viewer, filter and advanced filtering macros, multiple radar scan viewer; layer picking for automatic analysis of sub-layers; GPS and map track viewer including X, Y and Z axis and digital map importation Fig. 4.

Pipes, cables and buried objects can be automatically transferred to CAD and GIS formats allowing a complete subsurface GISbased digital map to be produced in just a few days Fig. 5.

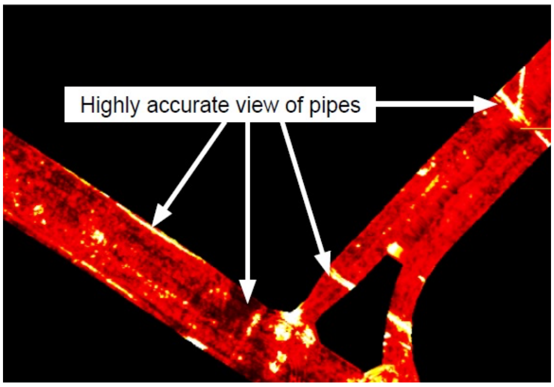

Fig. 3 – Gred HD data analysis.

Fig. 4 – Automatic CAD and GIS transfer.

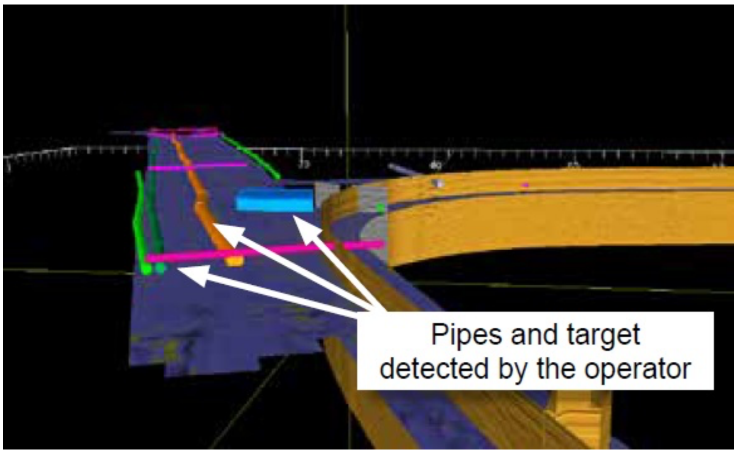

Fig. 5 – 3D post processing.

4. Types of works conducted

Next, we will review the types of works performed with these equipments in parallel with the classic detection equipment for confirmation or invalidate the results.

4.1 Detection of hidden utilities

A request was made for identification of concrete rainwater pipe route and PVC sewage pipe on Orhei street.

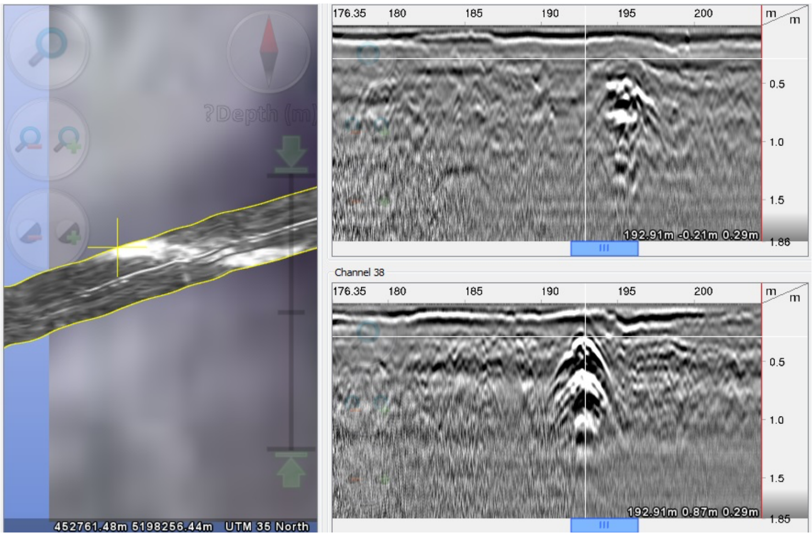

Fig. 6 – Main rainwater pipe.

Here we can clearly see from the scans even from a single pass with the device, the two pipes one of rainwater Fig. 6 and one of sewerage Fig. 7. The equipment performs a multitude of scans per second and unites them automatically, displaying an image just like the X-ray. The continuous structure is observed as well as the parable generated by the anomaly Fig. 7.

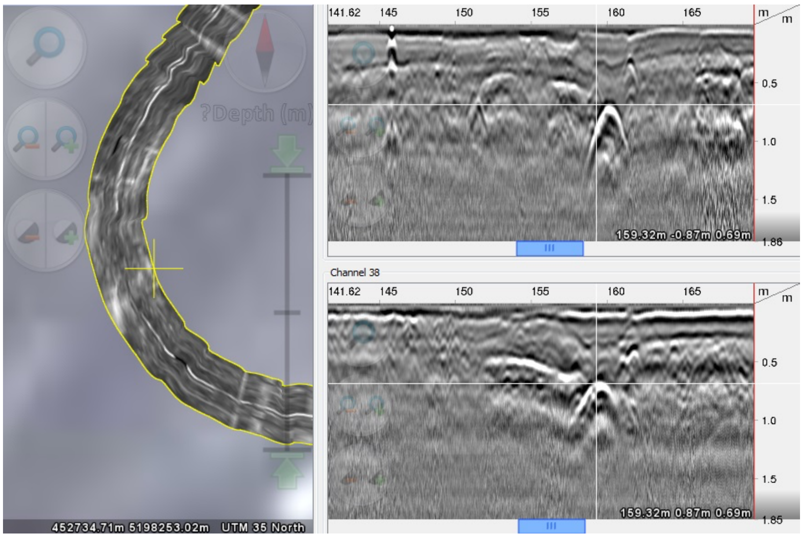

Fig. 7 – Sewage pipe.

Request was made for detection of the rainwater and sewage pipe on Mihai Stamatin Street with Rozelor.

This request regarding the detection of rainwater and sewage pipes, detection that proved a bit more difficult than usual due to the fact that in this area where the scan was performed, it was previously identified as a possible water loss.

Thus, high conductivity regions (> 10-7 S / m) cause disturbances that can be easily identified in geo-radar scanned graphs but they pose problems to the identification of pipes, therefore when using the geo – radar to scan the soil one should pay attention to what the device displays in the case of clay soil, any type of saltwater infiltration and generally any soil consisting of very fine-grained particles or high water concentration which may be misleading.

From the image Fig. 8 you can see the existence of the second pipe as well as the existence of a damage confirmed with the other devices.

The existence of two pipes could be confirmed and the existence of an anomaly probably due to water loss Fig. 9.

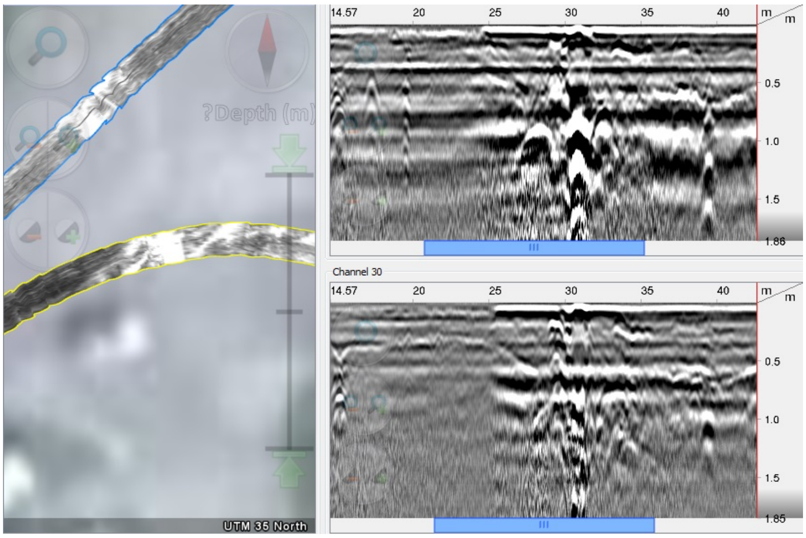

Fig. 8 – Two pipes.

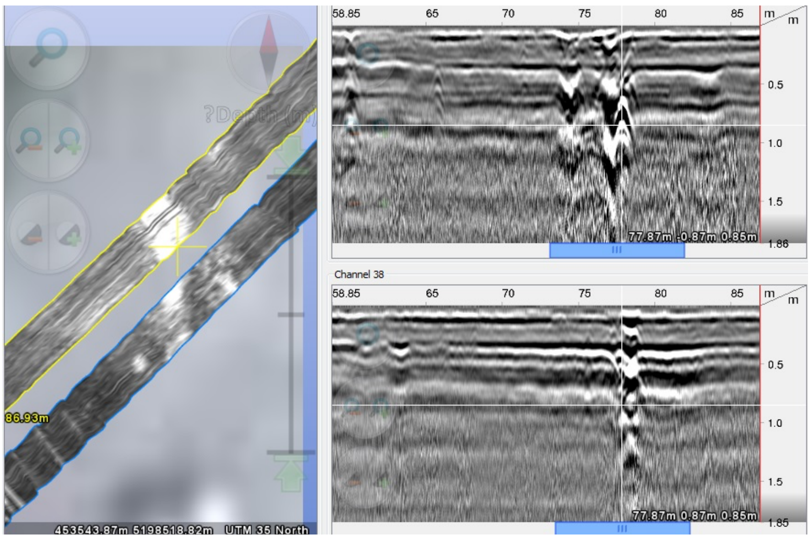

Fig. 9 – Presence of a water loss.

4.2 Detection of infiltrations and water losses

On the detection side of infiltrations and losses, a request was made to conduct survey and scans of infiltrations from the 9 Mai Street, where following four or five consecutive crossings with GPR, a rainwater manhole connected to the main sewage pipe was identified.

The source of the infiltration and the location could be identified, this being a rainwater manhole connected to the main sewage collector, and the source being groundwater Fig. 10.

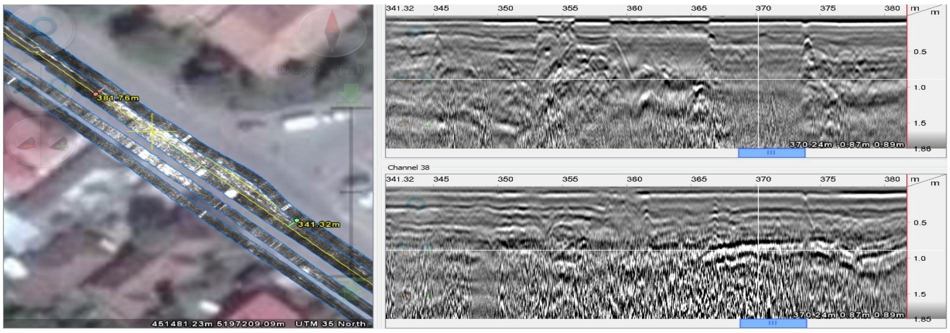

Fig. 10 – Source of the groundwater.

Furthermore, at a careful analysis of the scans it was possible to observe the existence of two water losses, one on the distribution pipe and the other on the main one respectively Dn 150 and Dn 400, damages that have been confirmed with the Hydrolux equipment.

You can also see the manhole of the sewage and rainwater as well as in the existing infiltration and connections to consumers Fig. 11.

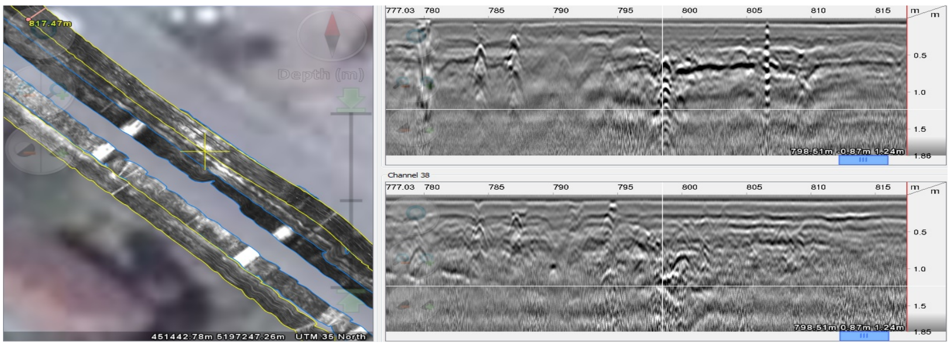

Fig. 11 – Existing infiltration.

Another type of loss detection request was made on Oituz Street in Piatra Neamt, where several problems were identified along the entire length of the street, such as losses on the distribution pipe and losses on the main one.

Once we scan the entire length of the street, we were able to identify problems in some areas, located on the distribution pipe as well as on the main one Fig. 12.

Damage to the main pipeline DN 500 steel and multiple water losses on the distribution pipe DN 80 steel Fig. 13.

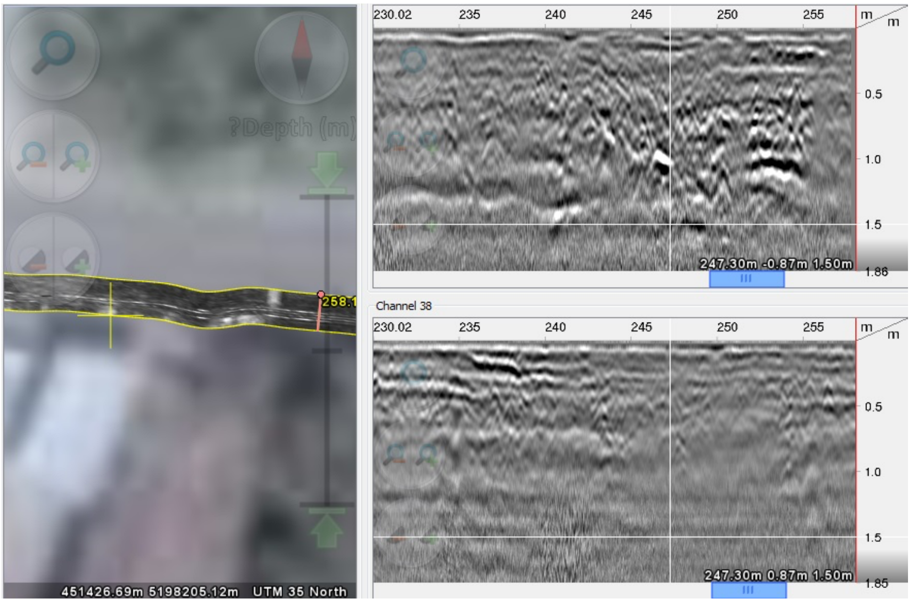

Fig. 12 – Identifying problems.

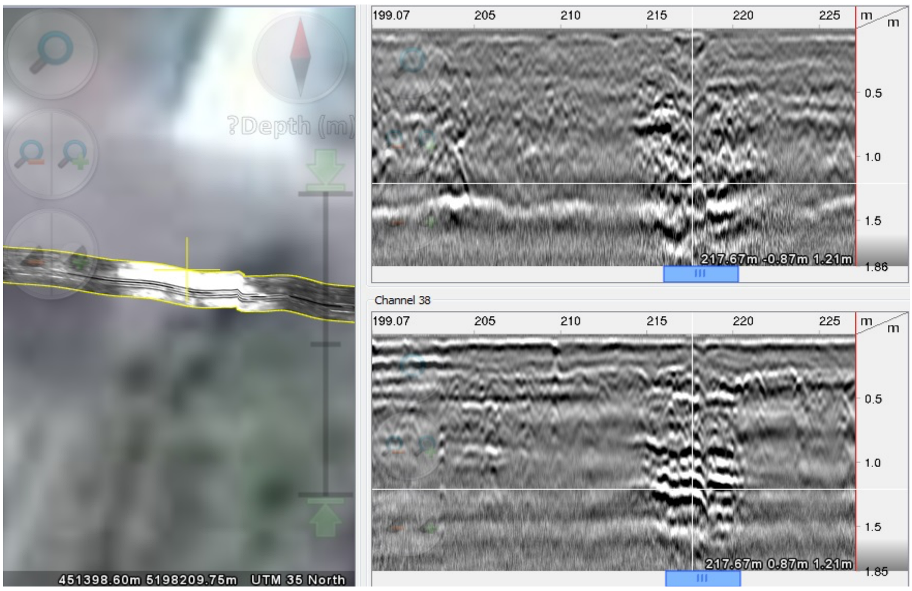

Fig. 13 – Water losses.

4.3 Detection of other anomalies (landslides, hidden manhole cover)

On the side of detection of other anomalies (landslides, hidden manhole cover) was a request for me to identify the location of the DN 500 steel pipe as well as of the hidden manholes on Republicii Boulevard.

It was possible to determine the emplacement of the pipeline but at the same time the possibility of a collapsed manhole, as well as the existence of a confirmed damage by other devices Fig. 14.

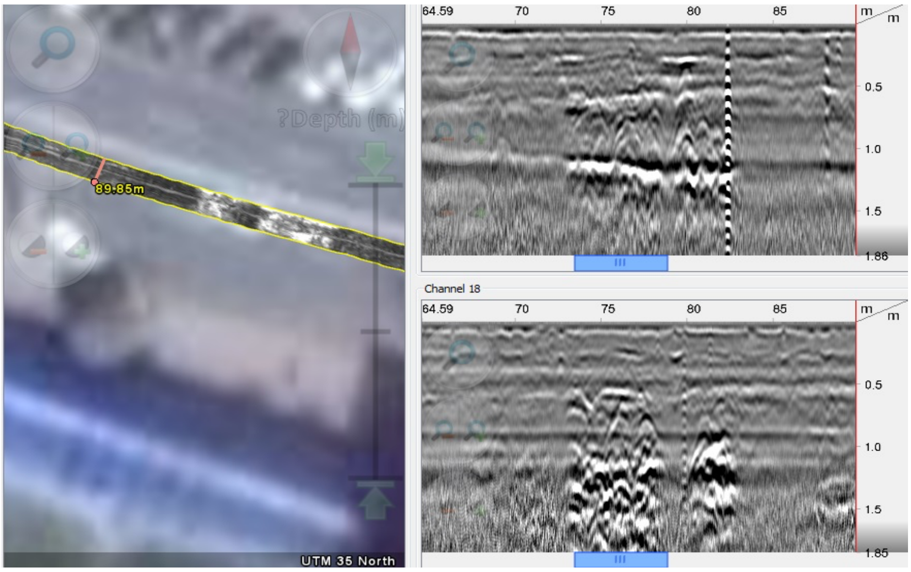

Fig. 14 – Emplacement of the pipeline.

Another peculiar request for us was to check the asphalt compaction on Petru Rares street, as a result of a repaired water losses done on a distribution pipe earlier.

Verifications concluded that, the compaction was performed correctly, as well as the corresponding pouring of the asphalt layer Fig. 15.

But looking at the scan further, we observed another damage to the drinking water supply network, damage to be scheduled for repairs Fig. 16.

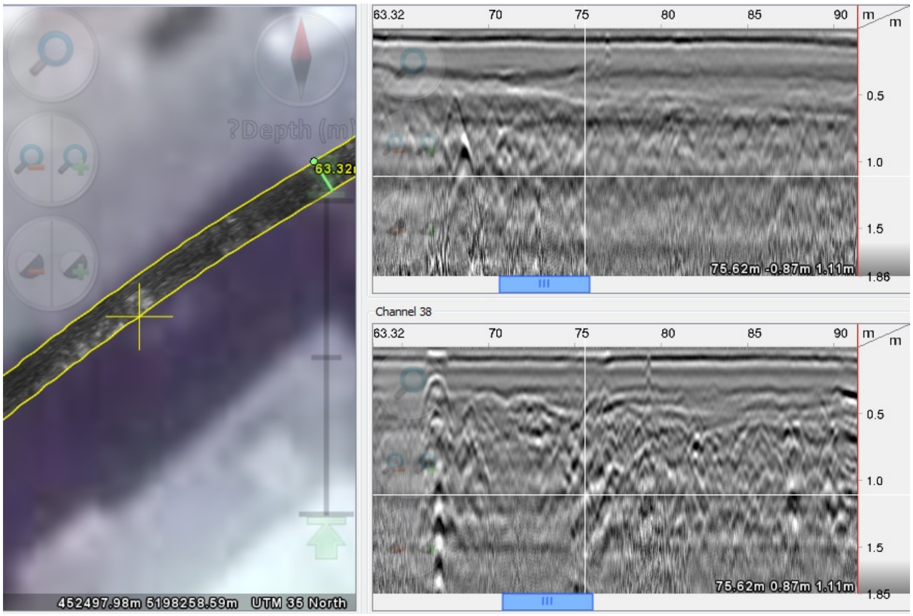

Fig. 15 – Compaction was performed correctly.

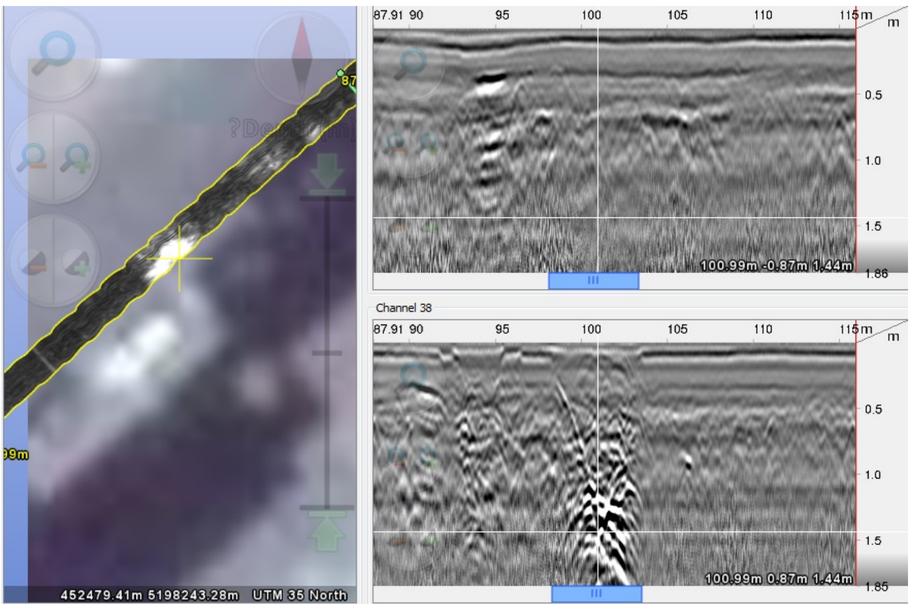

Fig. 16 – Further damage.

5. Results

There are some advantages and disadvantages using this equipment in the field.

As advantages I could mention the large coverage area of the scan due to its size having the width of 1.8m.

Among other advantages to mention would be the need to pass only once over the scanning area for data collection, the use in parallel with an RTK GPS system and displaying data in real time, respectively the modularity of the system.

Among the disadvantages are that it is a complex system by using many cables, which connect the antennas to the data processing unit, for the use of the equipment is recommended to be handled by at least 3 people, for data processing, 3D modeling and their export to the GIS system is required a high-performance process computer.

6. Conclusions

In conclusion, this paper analyzes the use of less atypical methods for identifying losses compared to conventional ones (using the method of listening with dedicated equipment) and should not be perceived as universal replacement of all the so far existing devices, as they are complementary devices on certain loss detection segments.

The influence of water losses, whether they are from the drinking water distribution pipes or from the domestic and rainwater sewers, on the surface layer also called the groundwater can be observed both by chemical laboratory analyzes and by the use (in some cases) of the GPR.

Thus, it can be observed through the radar analysis software from what depth the groundwater starts to be observed and from here (through subsequent analyzes depending on the area) conclusions can be drawn as to whether there are damages to the water pipes, sewer pipes or rainwater pipes, there is a risk that the groundwater could be contaminated.

Therefore the "unconventional" methods (compared to traditional sound-based detection methods) used in the field to identify pipe losses, can have good results as a secondary procedure for leak detection.

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STUDII SI CERCETARI PRIVIND PIERDERILE DE APA DIN RETELELE DE DISTRIBUTIE SI EFECTUL LOR ASUPRA PANZEI FREATICE

Lucrarea de fata prezinta posibilitatea utilizarii aparaturii din dotarea firmei la care lucrez G.P.R. (ground penetrating radar) U.A.V., camera termica, in detectia pierderilor de pe conductele de distributie si transport apa potabila, astfel Compania Judeteana APASERV incercand sa reduca procentul de pierderi, cat si cercetare privind influenta pierderilor asupra panzei freatice din diferite locatii. Utilizarea in teren a diferitelor tipuri de georadare cum ar fi georadar de joasa frecventa (de adancime) cu penetrare pana la 11 m adancime, georadarele cu multiple antene de frecventa in special cele cu 40 de antene sau mai multe pot ajuta la creearea unei imagini mai bune cu privire la eventualele retele de utilitati de sub pamant, cat si la prezenta eventualelor infiltratii, care pot proveni ori de la avarii de pe retele ori de la panza freatica. Aceste echipamente precum georadarul, drone si camerele termice, nu trebuie vazute ca pe un panaceu al tuturor echipamentelor existente pana in momentul de fata, nici pe parte de identificari pierderi nici pe parte de identificari utilitati, fiind o completare pe anumite segmente de detectie pierderi.